

## Further Information on *Gymnorhynchus isuri* (Trypanorhyncha: Gymnorhynchidae) from the Shortfin Mako Shark

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**ABSTRACT:** The morphology of the mature segments of *Gymnorhynchus isuri* Robinson, 1959, is described for the first time from specimens collected from shortfin mako sharks at Montauk, Long Island, New York. This species was found to possess a muscular cirrus sac with a conspicuous external seminal vesicle but no accessory seminal vesicle. It possesses an ovary that is tetralobed in cross-section, a uterus that is porally deviated and circumcortical vitellaria that are external to the longitudinal muscle bundles of the segment. Scanning electron microscopy of the scolex reveals that all types of microtriches are conspicuously absent from all regions of the scolex with the exception of the distal bothridial surfaces, which bear densely packed, filiform microtriches. The diagnosis of the genus *Gymnorhynchus* and family Gymnorhynchidae are emended to reflect these new data.

**KEY WORDS:** Gymnorhynchidae, *Gymnorhynchus*, mako shark, morphology.

In their recent reorganization of the poeciloacanthous trypanorhynch families, Beveridge and Campbell (1989) transferred the genera *Molicola* Dollfus, 1935, and *Stragulatorhynchus* Beveridge and Campbell, 1988, from the family Gymnorhynchidae to the family Molicolidae Beveridge and Campbell, 1989, leaving only the genera *Gymnorhynchus* and *Chimaerarhynchus* as valid gymnorhynchids. This resulted in a much more restricted and concrete family diagnosis; they proposed the group could thus be characterized by its possession of an accessory seminal vesicle and paired chainette elements each with a single lateral wing. Beveridge and Campbell (1989) provided a very detailed description of the scolex and segment morphology of the type and only known species of *Chimaerarhynchus*, *C. rougetae* Beveridge and Campbell, 1989. Although taxa now placed in *Gymnorhynchus* have been known since at least 1817, when Cuvier described *Gymnorhynchus gigas* (Cuvier, 1817) Rudolphi, 1819 (as *Scolex gigas*), the segment morphology of species belonging to this genus remains poorly known. Most reports of valid *Gymnorhynchus* species are of plerocerci (see, e.g., Cuvier, 1817; Dollfus, 1942; Brian, 1952; Seyda, 1976). The few existing reports of adult worms are generally not accompanied by descriptions or illustrations (see, e.g., Lopez-Neyra, 1947; Heinz and Dailey, 1974). Robinson (1959) provided a brief description and figure of a whole mount and cross-section of *G. isuri*, but because his material consisted entirely of a single immature specimen many details of mature segment morphology were unavailable. As a result, features such as the uterus and vitellaria have never been described for

this genus (see Campbell and Beveridge, 1994). Although the presence of an accessory seminal vesicle is included in the diagnosis of both the family and genus (see Campbell and Beveridge, 1994), to our knowledge this feature has never been confirmed in *Gymnorhynchus*.

The collection of specimens of *Gymnorhynchus isuri* from the spiral intestines of shortfin mako sharks taken at shark tournaments at Montauk, Long Island, New York, provided us with the opportunity to investigate the morphology of this genus in more detail. These specimens also allowed us to investigate details of the scolex of this species using scanning electron microscopy (SEM).

### Materials and Methods

Specimens of *Gymnorhynchus isuri* were removed from the spiral intestines of shortfin mako sharks, *Isurus oxyrinchus* Rafinesque, 1809, landed at the Star Island Yacht Club, Montauk Marine Basin, and Montauk Boatman's and Captain's Association shark-fishing tournaments at Montauk, Long Island, New York, in August 1992, 1993, and 1994. The strobila of all tapeworms were flattened on black plastic cards in a thin film of distilled water and then fixed in this flattened condition by pipetting warm alcohol/formalin/acetic acid (AFA) onto the plastic. Worms were fixed in AFA overnight and then transferred to 70% ethanol for storage.

The scolex and part of the strobila of 1 specimen of *G. isuri* was prepared as a whole mount to determine the location of immature, mature, and gravid segments in these very long worms. Based on information obtained from this initial mount, 9 portions of the strobila containing approximately 3 mature segments each were separated from the strobila of a second specimen. A razor blade was used to cut a very shallow frontal section from each of these strobilar fragments such that the surface musculature and vitellaria were removed,

but the bulk of the segment morphology remained intact. This greatly facilitated illustration and description of the internal segment morphology. These dorsal and ventral portions of the strobila were prepared as whole mounts. In each case, these 2 portions were mounted next to one another on the same slide. Whole mounts were stained in Gill's hematoxylin, cleared in xylene, and mounted in Canada balsam according to conventional techniques.

Three portions of the strobila of the third specimen, again identified as bearing mature segments based on the morphology of the first whole mount, were embedded in paraffin. Cross-sections were cut at 10- $\mu$ m intervals with an American Optics rotary microtome. Sections were stained in eosin and Gill's hematoxylin, cleared in xylene, and mounted in Canada balsam according to conventional techniques.

Scolices of 3 specimens were removed from the strobila, hydrated in a graded ethanol series, placed in 1% osmium tetroxide overnight, dehydrated in a graded ethanol series, and dried using Peldri II (Ted Pella, Inc., Redding, California) according to Freidenfelds et al. (1994) or critical point-dried with liquid CO<sub>2</sub>. All specimens were subsequently mounted on stubs with silver paint or carbon tape, sputter-coated with 100–300 Å of gold, and examined with a Coates and Welter Field Emission Scanning Electron Microscope.

All illustrations were done with the aid of a drawing tube. All measurements are given as the range followed in parentheses by the mean plus or minus the standard deviation, the number of specimens measured ( $n$ ), and the number of observations ( $\underline{n}$ ) when more than 1 structure was measured per specimen. All measurements are given in micrometers unless otherwise stated. Voucher specimens, including an unmounted intact scolex, and slide material of whole mounts and cross-sections were deposited at the U.S. National Parasite Collection in Beltsville, Maryland (USNPC Nos. 85936–85939). The stubs examined with SEM were retained in the senior author's personal collection. For comparative purposes, the holotype of *G. isuri* was borrowed from the National Museum of New Zealand, and larval material of *G. gigas* from *Brama rayi* was borrowed from the British Museum (BM Nos. 1976.4.14.15 and 1961.9.1.17–20).

## Results

Four of 19 shortfin mako sharks examined were found to host *Gymnorhynchus isuri*. Three sharks hosted 1 individual and 1 shark hosted 2 individuals of this cestode. All 5 cestodes found were fully mature, possessing both mature and gravid segments. The infected sharks ranged in weight from 248 to 626 lb; none of the 13 sharks weighing less than 200 lb examined were infected with this trypanorhynch species.

### *Gymnorhynchus isuri* Robinson, 1959

(Figs. 1–3)

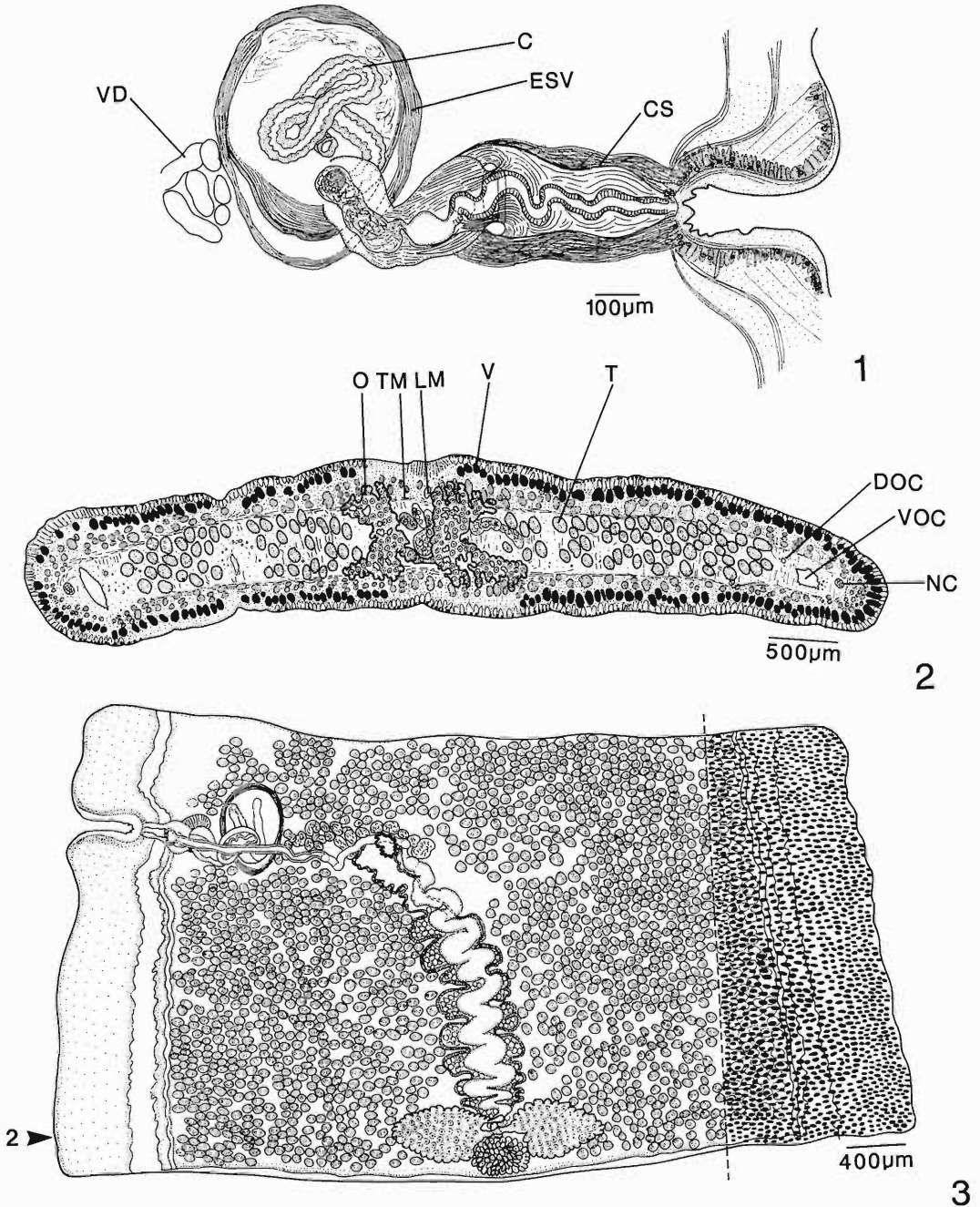
SYNONYMS: None.

The following information, based on 4 mature specimens, should emend the description of

*Gymnorhynchus isuri* provided by Robinson (1959).

Surfaces of pars bulbosa, pars vaginalis, apex of scolex, and proximal bothridial surfaces entirely devoid of microtriches. Distal bothridia surfaces with densely packed, slender, filiform microtriches.

Mature segments 3,140–3,923 ( $3,498 \pm 431$ ,  $n = 3$ ,  $\underline{n} = 10$ ) long by 4,776–5,243 ( $5,038 \pm 207$ ,  $n = 3$ ,  $\underline{n} = 10$ ) wide; gravid segments 2,060–3,427 ( $2,766 \pm 802$ ,  $n = 3$ ,  $\underline{n} = 10$ ) long by 3,794–5,875 ( $5,022 \pm 1,086$ ,  $n = 3$ ,  $\underline{n} = 10$ ) wide. Strobila acraspedote; genital pores marginal, alternate irregularly, 76.9–82.9% ( $80.1 \pm 2.56$ ,  $n = 3$ ,  $\underline{n} = 10$ ) of segment length from posterior end. Genital atrium surrounded by sphincter-like condensation of muscular elements. Cirrus sac (Fig. 1) elongate, 244–376 ( $295.8 \pm 82$ ,  $n = 3$ ,  $\underline{n} = 10$ ) long by 802–878 ( $820 \pm 39.4$ ,  $n = 3$ ,  $\underline{n} = 10$ ) wide, walls very muscular; muscle fibers merging with genital sphincter; cirrus unarmed, retracted cirrus projecting into external seminal vesicle. External seminal vesicle (Fig. 1) oval, with thick muscular wall, 571–714 ( $611 \pm 68.7$ ,  $n = 3$ ,  $\underline{n} = 10$ ) long by 387–591 ( $458 \pm 90.6$ ,  $n = 3$ ,  $\underline{n} = 10$ ) wide. Accessory seminal vesicle absent. Vas deferens coiled medially, entering external seminal vesicle medially. Testes very numerous, at least 1,400 in number, oval, 40.3–80.6 ( $51.9 \pm 21.9$ ,  $n = 3$ ,  $\underline{n} = 18$ ) long by 64.5–111.4 ( $77.2 \pm 23.4$ ,  $n = 3$ ,  $\underline{n} = 18$ ) wide, intervascular, distributed throughout medulla in 3–4 dorsoventral layers, interrupted by ovary, uterus, and male genitalia, some follicles posterior to ovary, never confluent posterior to ovary. Vagina tubiform, sinuous, extending from ovarian isthmus to level of cirrus sac then lateral toward cirrus sac, enters genital atrium ventral to cirrus sac. Seminal receptacle absent. Ovary bilobed in dorsoventral view, tetralobed in cross-section (Fig. 2), 363–469 ( $416 \pm 41$ ,  $n = 3$ ,  $\underline{n} = 10$ ) long by 1,162–1,418 ( $1,305 \pm 82.2$ ,  $n = 3$ ,  $\underline{n} = 10$ ) wide. Mehlis' gland conspicuous, posterior to ovarian isthmus. Uterus tubular, median, ventral to vagina, anterior extremity porally deviated in immature and mature segments (Fig. 3), terminating just porally of median line at level of seminal vesicle; preformed uterine pore absent. Uterus becomes saccate with 8–11 lateral branches on each side, losing poral deviation in fully gravid segments. Vitelline follicles circumcortical, interrupted by ovary. Longitudinal muscles arranged in numerous bundles throughout perimeter of segment, internal to vitelline



Figures 1–3. *Gymnorhynchus isuri* from *Isurus oxyrinchus*. 1. Detail of male terminal genitalia. Vagina is not shown. 2. Cross-section through mature segment at level of ovary. 3. Mature segment. Dorsal surface has been removed to permit viewing of segment morphology. Vitellaria are circumcortical but are drawn only to the reader's right of the vertical dashed line. Arrow indicates location at which the section shown in Figure 2 was taken. Note: There is no preformed uterine pore; circular structure at anterior end of uterus is an artifact resulting from the removal of the dorsal surface of the segment. C = cirrus, CS = cirrus sac, DOC = dorsal osmoregulatory canal, ESV = external seminal vesicle, LM = longitudinal muscle, NC = nerve cord, O = ovary, T = testis, TM = transverse muscle, V = vitellaria, VD = vas deferens, VOC = ventral osmoregulatory canal.

follicles. Transverse muscles weakly developed, immediately internal to longitudinal muscle bundles. Osmoregulatory canals paired; dorsal canals much smaller than and internal to ventral canals. Eggs slightly oval, 43–45 ( $44 \pm 0.8$ ,  $n = 3$ ,  $\bar{n} = 15$ ) long by 37–41 ( $39.3 \pm 2.2$ ,  $n = 3$ ,  $\bar{n} = 15$ ) wide.

### *Gymnorhynchus Rudolphi*, 1819

The following information should supplement the most recent diagnosis presented by Campbell and Beveridge (1994) for this genus.

Strobila acraspedote. Segments wider than long. Testes numerous, intervacular, distributed throughout segment, some post-ovarian. Genital pores irregularly alternate. External and internal seminal vesicle present; accessory seminal vesicle absent. Vagina ventral to cirrus sac. Uterus arches toward genital pore. Preformed uterine pore absent. Vitelline follicles circumcoritcal, external to longitudinal muscle bundles.

### Discussion

At this point, only 2 valid species of *Gymnorhynchus* are known: *G. gigas* and *G. isuri*. As the former is known only from larval material and the latter only from adult material, they can be distinguished solely on the basis of scolex morphology at this time. Among the criteria provided by Robinson (1959) to distinguish these 2 species, we found the number of hooks in the basal armature to be the most conspicuous; whereas *G. gigas* has approximately 18 large hooks in its basal armature, *G. isuri* has only 8 or 9. Our data suggest that adults of *G. isuri* are parasites of larger mako sharks.

Overall, the segment morphology of *Gymnorhynchus* is very similar to that of *Chimaerarrhynchus*. However, several interesting differences in segment morphology exist between these 2 genera. Whereas *Chimaerarrhynchus* has an ovary that is bilobed in cross-section, *Gymnorhynchus* has an ovary that is clearly tetralobed in cross-section. Whereas the vitellaria in *Chimaerarrhynchus* alternate with the longitudinal muscle bundles, the vitellaria in *Gymnorhynchus* are external to the longitudinal muscle bundles. Perhaps most importantly, although *Chimaerarrhynchus* possesses an accessory seminal vesicle, *Gymnorhynchus* does not, thus the diagnosis of the family Gymnorhynchidae provided by Campbell and Beveridge (1994, p. 78) should be slightly emended from "accessory seminal vesicle present" to "accessory seminal vesicle pres-

ent or absent." We have emended the generic diagnosis above to reflect this finding.

SEM of the scolex of *G. isuri* reveals a surface bearing few structures. We were unable to find any evidence of palmate microtriches on any of the surfaces of the scolex of this species. In fact, no microtriches were seen on the surfaces of the pars bothridialis, pars vaginalis, apex of the scolex, or the proximal bothridial surfaces. Although the fact that slender filiform microtriches were seen on the distal bothridial surfaces argues against specimen mistreatment as the explanation for this result, this finding is so unusual for a cestode that we examined a scolex from each of 3 separate field collections to ensure that this result was not an artifact of fixation or specimen treatment. The microtrich pattern was the same in all 3 specimens. These data contradict the proposal that palmate microtriches should be considered to be a synapomorphy for the trypanorhynchs, as was suggested by Richmond and Cairns (1991), because this feature is absent from *Gymnorhynchus*. To our knowledge, *Gymnorhynchus isuri* is by far the largest cestode yet to be examined with SEM, its scolex being approximately 1 cm in length. It would be interesting to examine the surfaces of the scolex of other similarly sized cestodes to see whether or not this lack of microtriches is correlated with size. The exact function or functions of microtriches remains poorly known. Perhaps one or more functions are not required by a worm of this size.

### Acknowledgments

We thank Dr. Ian Beveridge for his assistance with the interpretation of the terminal genitalia of this species. We would also like to thank David Gibson and Ricardo Palma for lending specimens. We are especially grateful to Sam Gershowitz of the Star Island Yacht Club, Carl Darnenberg of Montauk Marine Basin, and Joe McBride and the Montauk Boatman's and Captain's Association for allowing us to dissect shortfin mako sharks at their shark tournaments in 1992–1994.

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J. Helminthol. Soc. Wash.  
63(2), 1996, p. 192

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Total .....	\$794.03
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